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ABSTRACT

The purpose of this study was investigate the effects of a DNA Fingerprinting Workshop on 10th grade students' self efficacy and attitudes toward science. The content of the workshop based on high school science curriculum and includes multimedia instruction, laboratory experiment and participation of undergraduate students as mentors. N=93 students from 4 different schools participated in the three day DNA Fingerprinting workshop. Students' self efficacy and attitudes toward science were measured with a 15-item Likert scale instrument designed for the study. Analysis indicated that females tend to be less confident compared to male students before the workshop. This gender gap closed down after the workshop and we did not identify any difference between genders in students' self-efficacy and attitudes toward science based on post test scores. (Author)

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Investigating the effects of a DNA Fingerprinting Workshop on 10th Grade Students' Self Efficacy and Attitudes toward Science.

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Abstract

The purpose of this study was to investigate the effects of a DNA Fingerprinting Workshop on 10th grade students' self efficacy and attitudes toward science. The content of the workshop based on high school science curriculum and includes multimedia instruction, laboratory experiment and participation of undergraduate students as mentors. N=93 students from 4 different schools participated in the three day DNA Fingerprinting workshop. Students' self efficacy and attitudes toward science were measured with a 15-item Likert scale instrument designed for the study. Analysis indicated that females tend to be less confident compared to male students before the workshop. This gender gap closed down after the workshop and we did not identified any difference between genders in students' self-efficacy and attitudes toward science based on post test scores.

Introduction

During the age of major scientific discoveries such as the Human Genome Project, it is vital for students to develop an understanding and appreciation for scientific literacy. Today science education provides students with real life opportunities that allow them to use critical thinking and problem solving skills through hands on approaches and active learning. Nevertheless, there is still a gap between science and science education. It is often difficult for students to understand the relationship between real life science and the content of science education. This lack of understanding causes students to question the importance of learning the materials taught in schools and most of the time, "real science" is isolated and not accessible to students.

"....establishing a foundation for developing understanding of molecular biology at the high school level" (p. 155).

"Because molecular biology will continue into the twenty-first century as a major frontier of science, students should understand the chemical basis of life.....(p. 181).

These statements are taken from the National Science Education Standards stating the importance of molecular biology in the high school science curriculum. Unfortunately, in some cases biology is considered as a non-laboratory science and taught that way by teachers. Reed (2001) comments that "students who leave high school today without having been exposed to some form of DNA technology have been cheated out of an important experience". Limitations such as accessibility to adequate equipment necessary for conducting laboratory experiments, the amount of time devoted to students' exposure to the latest technology or to an understanding of scientific problems can be considered as the reasons for the students' lack of confidence, motivation and low achievement.

Self-efficacy is an individual's belief in his/her ability to achieve a targeted goal in a task. How we approach to new tasks is mostly defined by our self-efficacies. In the social cognitive theory self-efficacy has been considered as one of the main contributors to student achievement. According to Bandura (1994), individuals with higher self-efficacy levels approach to difficult tasks as challenges to be mastered rather than as a threat. These people show a strong commitment to their tasks. However, individuals with low levels of self-efficacy tend to view challenges as threats and shy away from them. These individuals have weak commitments and easily lose faith. (Bandura, 1994). The effects of self-efficacy on human functions were identified by Albert Bandura under four categories: behavior choices, thought patterns, humans' view of behaviors, and efforts applied to a task. For students these effects present themselves as career choices, motivation for subject matter and in our case attitudes toward science. According to his argument self-efficacy increases by performance accomplishment, observing others successful tasks support and encouragement from others, and decreasing the amount of anxiety during a task.

Luzzo et al (1999) report positive effects of performance accomplishment treatment on students' self-efficacy and math/science interest. Students who are identified as disadvantaged based on certain criteria such as socioeconomic status are the ones most likely to show negative attitudes toward science and to have low self-esteem. These factors then negatively affect their ability to understand what real life science is

and how connected it is to our lives. Pajares (1996) describes how individuals' behaviors are affected by their beliefs on about their abilities and are reflected in their career choices or the amount of time spent on particular tasks, and how persistent they will be in confronting obstacles.

The factors such as gender, ethnicity have been proved to have effects on self-efficacy perceptions. Carter, Sottile, and Carter (2001) reports on the differences among boys and girls' self–efficacy perceptions. Under-representation of females and minority groups especially in science areas has been pointed out and investigated in many studies and that reported that when compared to males, females are at a distinct disadvantage due to social and cultural stereotypes. As Smist & Owens (1994) explain "social cognitive theory predicts that if attitudes toward science, attributions about science success, and, especially, science self-efficacy can be improved, females, and minorities might be more attracted to science as a profession". Until recently women's career choices were limited to being a teacher, nurse or social worker. These were considered to be the only suitable jobs for females (Samuels, 1996). Females are also presumed to be irrational or to avoid competition, neither of which is a characteristic of a scientist (Samuels, 1996). These inaccurate stereotypes need to be addressed if females are to develop self-efficacy regarding science achievement. Lent, Brown and Larkin (1986) report on self-efficacy's significance predictive role on science and engineering grades. Ryckman and Peckman (1987) reports gender differences in attributions for science among elementary secondary education students and females are reported to ascribe their success to effort where males to ability in mathematics and science.

About the Workshop

Outreach programs provide opportunities for active learning experiences and in many cases involve college students or faculty going into K-12 classrooms and giving workshops for students and their parents (Joesten and Tellinhuisen, 2001). The DNA Fingerprinting Workshop is a three-day outreach program developed and offered by the Molecular Genetics Department Schools of Biological Sciences at a state university with the cooperation of the Science Curriculum Supervisor of a Public School district in the Midwest area.

The DNA fingerprinting workshop creates an environment where 10th grade high school students work with undergraduate mentors cooperatively. The main goal of the workshop is to show students how DNA analysis is conducted in real-world context and how the outcome of these analysis is used in the decision making process by exposing them to scientific technologies and hands on electrophoresis technology. Our hope is that with opportunities such as this DNA fingerprinting workshop students can make connections between the context material in the classroom and how science works in real life, and through performance achievement they can increase their self-efficacy and develop positive attitudes toward science.

The elements of the workshop includes; multimedia instruction, which consists of a PP presentation on DNA structure, restriction enzymes, and DNA fingerprinting. A short video of a crime story in the style of the X–Files follows the presentation and was produced by theater major undergraduate students. Four suspects are identified at the end

of the story and participating high school students (acting as forensic scientists working for a government agency) are responsible for solving the mystery by conducting DNA analysis. First physical and psychological traits are used to make a decision on the identity of the criminal, which is followed by the DNA analysis. During the experiment students analyzed and compared the sample that was supposedly retrieved from crime scene to the samples from each suspect. Electrophoresis experiments are conducted in groups of 4-6 based on the number of students in classrooms. Each station has the instruments a power pack, gel box, centrifuge, pipetman, pipet tips, set of tubes and a gel. Undergraduate students serving as mentors, initiate discussions on how DNA Fingerprinting analysis is used in forensic sciences, how effective these methods are, the impacts biotechnology has on society and ethics, while the electrophoresis is running. Mentors are specifically instructed not to touch anything as long as it is not necessary and is let high school students set up the equipment, load the gels and run the analysis by following written procedures. Mentors also serve as role model for the high school students showing them that studying science and a career in basic sciences is an achievable goal. It is important to get successful results from all stations to provide a successful performance accomplishment for all students. Although even being able to complete the task and running electrophoresis provides a satisfaction to high school students, being able to identify the criminal with their own station's results increases their self-confidence due to fact that they were successfully completed the experiment and identify the criminal. After the workshop all students discusses human genome project and possible effects in our lives in an open platform.

This paper presents an exploratory pilot study. The main purpose was to evaluate a questionnaire developed to assess students' self-efficacy and science attitudes and with the available data explore the relationships between dependent and independent variables.

Methods

A questionnaire was developed modeling Baldwin, Ebert-May and Burns's (1999) "Biology Self-Efficacy Instrument: and the "Students Ideas about Science and Science Learning" used by Stratford and Finkel (1996) to measure students' attitudes toward science and genetics and their level of self-efficacy. This 15 item Likert-scale questionnaire (5= strongly agree and 1= strongly disagree) was administered to participating n= 93 10^{th} grade students from four schools before and after the DNA Fingerprinting analysis. Because of limited sources available, the number of participant schools was kept limited to four. Each student was identified with a four digit identification number in for the purposes of matching them on the pre- and post- tests. Only 76 of the questionnaire were paired after the post test due to non-attendance to post-test or un-matching code numbers.

Our research question was "Is there any change present in students' self-efficacy and attitudes toward science caused by the DNA fingerprinting workshop?" In pretest results we observed a ceiling effect which leaves very little room for positive change that might effects the significance levels. One of the items was removed from the questionnaire because of the negative correlation with other items. Reliability analysis of

the instrument revealed an alpha level of .9011. Two subscales were taken into consideration during the development of the survey; self-efficacy and attitudes. Analysis showed that these subscales have moderately high correlation levels (.64) indicating that they are not independent of each other. The questionnaire, as a whole, was used as a scale to calculate mean scores for further analysis.

The objective of this was exploratory in nature. One of the assumptions that was not met and risking internal validity of the analysis was random sampling of the subjects. Students who participated in the study were selected based on their schools' willingness to participate to the study. Therefore results reported in this section cannot be generalized to all 10^{th} grade high school students population. Homoscedasdicity assumption was tested with Levene's test and variance ratio (Fmax). Although cell variances in descriptive statistics indicated heteroscedasdicity with Fmax value of 2.87 since Levene's test for analysis of variance was not significant and meets the assumption. Alpha level kept as .05 for further analysis but we recommend cautious interpretation of results. Repeated measures of ANOVA had significant findings for the pre- and post-tests and by gender [$F= 18.61$, $p<.01$ and $F=7.924$, $p<.01$]. No interaction or school effect was significant. The observed power for gender was .79. Independent sample T test was used to determine where the gender difference exists. Pre-tests analysis had significant results [$t(74) = -2.36$ $p=.02$] indicating a difference between males and female students. The mean score of males' was 3.87 and females' was 3.48. Post-tests analysis results were not significantly different for the comparison of females and males. The individual survey item analysis revealed an increase of mean scored in post-test compared to pre-test scores. This result suggests a positive workshop effect closing the gaps between females and males with an improvement in females' self-efficacy and attitudes toward science. This improvement can be attributed to students' positive experience during the DNA fingerprinting experiment which is a demonstration of how science works in real life and understanding its relationship with the content knowledge taught in schools.

During the 3-day workshop we observed great enthusiasm among the high school students resulted with full attendance was which is identified as a problem through the year by teachers. Students were willing to conduct the experiment with participation to the every step of the experiments.

Conclusion

The DNA Fingerprinting workshop provides opportunity for high school students to experience scientific technology used in genetic analysis, understand how real-world science works and question the genetic analysis from social and ethical perspective critically. This pilot study was exploratory in nature and was designed to evaluate the instrument and serve as a background for future research. The results of the study showed a significant difference between pre-test and post-test, and female students had significantly low scores compared to males in the pre-test. Post-test analysis showed no significant difference between genders suggesting a positive workshop effect on self-efficacy and attitudes.

One of the biggest limitations of the study was the lack of a qualitative component which can provide more input in the decision making. We believe that adding a

qualitative component to the study will provide valuable information and insight on students self efficacy and attitudes toward science. There was no control group to compare our result with and some parameters were excluded from study which could provide more information such as ethnicity, socioeconomic status or GPA. We suggest further research to investigate the relationship between self-efficacy and science attitudes with real-world science experiences is warranted.

			Mean	SD

School 1	female	Mean pre	3.60	.74
		Mean post	3.95	.65
	male	Mean pre	3.80	.49
		Mean post	3.93	.43
School 2	female	Mean pre	3.10	.84
		Mean post	3.51	.98
	male	Mean pre	3.57	.83
		Mean post	3.64	.74
School 3	female	Mean pre	3.73	.51
		Mean post	3.85	.62
	male	Mean pre	3.98	.54
		Mean post	4.05	.52
School 4	female	Mean pre	3.38	.83
		Mean post	3.68	.69
	male	Mean pre	4.30	.71
		Mean post	4.31	.61

Table 1: Mean scores

	df	F
gender	1	7.924*
school	3	.295
gender*school	3	.225

*p<.05

Table 2: Repeated measures of NAOVA for school, gender and interaction effect

	df	t	
Mean pre-test	74	-2.316*	
Mean post-test	74	-.850	

*p<.05

Table 3: t-test analysis for pre and post test mean scores.

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